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Barren Island Dredged Material Placement for Regional Sediment Management

by Robert N. Blama

PURPOSE. This Coastal and Hydraulics Engineering Technical Note (CHETN) describes activities that have occurred in the Chesapeake Bay to assist with Regional Sediment Management (RSM) activities by the US Army Corps of Engineers Baltimore District, Baltimore, MD. The Baltimore District employs the beneficial use of dredged material, specifically at Barren Island in the Chesapeake Bay, to prevent erosion of the remote island. This CHETN describes the beneficial use of dredged material at Barren Island. Finding a cost-effective, environmentally acceptable disposal site for the dredged materials is a challenge for all dredging projects, particularly for small navigational dredging projects. One such project is the Honga River and Tar Bay small navigation project in the Chesapeake Bay. An eroding barrier island that is protecting the mainland is located close to this Federal project. This technical note describes the use of geotextile tubes and dredged material to accomplish the Baltimore District's Operation and Maintenance (O&M) dredging mission for the Federal navigation project, while also using the material dredged from that project to prevent further erosion at Barren Island. Beneficial use of dredged material is one component of RSM activities in the Baltimore District.

BACKGROUND. Barren Island is an uninhabited island located in the Chesapeake Bay in Dorchester County, MD, near the Honga River and immediately west of Hoopers Island (Figure 1). This island is located at approximately 38° 20.4' N latitude and 76° 15.7' W longitude (Maryland State Plane Coordinates N 246,000 E 1,524,000). There are conflicting reports about the historical acreage of Barren Island. Kearney and Stevenson (1991) report Barren Island to be approximately 700 acres in 1660. A State of Maryland (1949) study set the Island at 839 acres in 1848, while Wray et al. (1995) proposed that Barren Island was 754 acres during the same time. Given these discrepancies, Barren Island has lost between 74 and 78% of its historical acreage to erosion. Currently, Barren Island consists of three eroding island remnants totaling about 180 acres in size (197 acres including tidal flats), according to the Maryland Port Administration (2005). Barren Island has a very low topographic relief with a maximum elevation of 6 ft above mean high tide (MHT). Shoreline erosion has caused Barren Island to lose approximately 520 to 660 acres. The island is Federally owned and managed by the US Fish and Wildlife Service (USFWS) as a satellite refuge area to Blackwater National Wildlife Refuge. The USFWS estimates that Barren Island is eroding along its western shore at a rate of approximately 10 to 14 ft per year, which is about equal to a loss rate of 2.4 to 3.4 acres per year. Figure 1 illustrates the historic footprints of Barren Island. Barren Island could be substantially eroded in 69 years, given its current long-term erosion rate of 14 ft per year.

Barren Island acts as a buffer to the mainland and protects the developed shoreline of Hoopers Island from erosion. The island is best described as two lobes (northern and southern) connected via a thin shrub-covered tidal flat. Originally, Barren Island was actually not an island, but rather part of the central Delmarva Peninsula that jutted into the Chesapeake Bay from the eastern shore.

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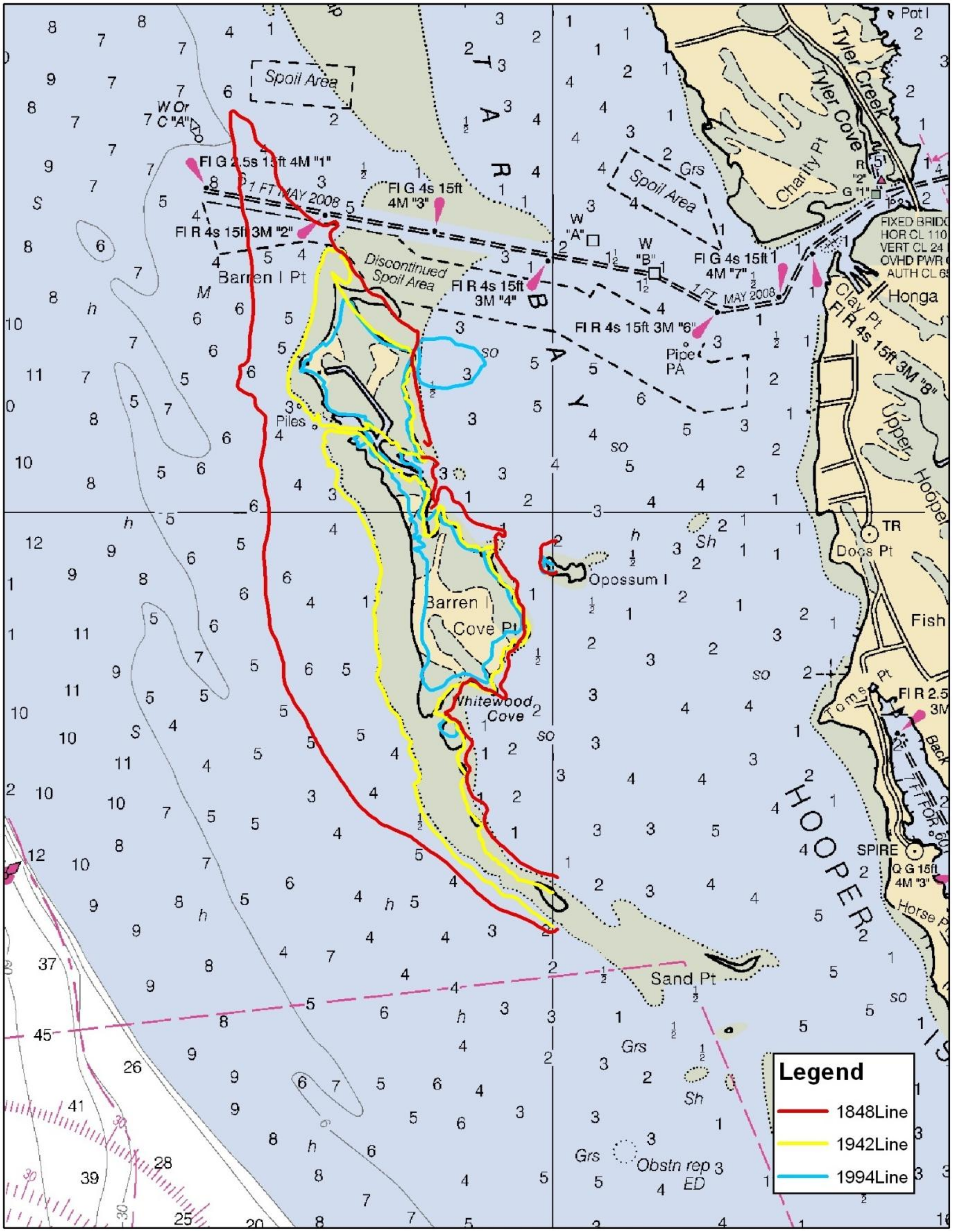

Figure 1. Barren Island historical footprints, and Federal channel at Honga River, Chesapeake Bay, Maryland.

Over the past several hundred years, erosion and overwash episodes induced by storm surges, formed several small connections from the main body of the estuary into what is now known as the Honga River. These small tributary connections slowly grew under tidal forcing and currents, creating an island chain that reached from the central Chesapeake Bay region to the southern region in a longitudinal orientation. The main geologic component of this peninsula is of clay origin and not silica sediments (sand) typical of coastal islands. Due to this extremely fine grain clay composition, the island chain has eroded very quickly with rise in sea level, and has recently seen more accelerated erosion rates with the introduction of waves created by large vessel wakes.

Barren Island is exposed to wind-generated waves from all directions. Radially-averaged fetch distances were computed for each wind direction using the US Army Corps of Engineers computer application Automated Coastal Engineering System (ACES). Wave hindcast results for offshore significant wave height from the south (longest fetch) range from 6.7 ft for a 5-year storm to 11.3 ft for a 100-year storm. Results for peak spectral wave period range from 5.7 sec for a 5-year storm to 7.3 sec for a 100-year storm from the south (US Army Corps of Engineers 2008). Barren Island consists of several different types of high quality habitat including low and high salt marsh, tidal flats, and forested upland habitat consisting of a mix of coniferous and deciduous trees that support a heron rookery. On the lee side of the island are extensive sea grass beds dominated by *Ruppia maritima*.

Although geotextile tubes have been installed and some wetland restoration has occurred along the northern and western shorelines, the island continues to erode. Relatively little upland areas remain on Barren Island, and what does remain is being continually eroded, as indicated by steep banks and fallen trees (Maryland Port Administration 2004). Western shorelines unprotected by geotubes appear to be the most affected by erosion (Maryland Port Administration 2005).

BENEFICIAL USE OF DREDGED MATERIAL TO RESTORE BARREN ISLAND HABITAT. A Federal navigation channel is located north of Barren Island and extends from the Chesapeake Bay into the Honga River (Figure 1). The maintenance cycle for this channel is approximately every 4 years. The amount of sediment removed in a typical dredging cycle ranges between 80,000 and 120,000 cu yd.

Placement sites have always been a problem for small navigation projects that are only occasionally dredged. Since Dorchester County ranks first in abundance of coastal wetlands in the mid-Atlantic region, upland sites for placement are almost non-existent there. Open water placement is not an option for placement of material as it is not allowed in the State of Maryland. Because the shoreline of the isolated Barren Island was rapidly eroding, it was determined that placement of dredged material could help slow down the erosion. The State of Maryland will not allow placement of fine grain sands and silt into the system unless there is a containment structure to hold the fines. Because rock breakwater is exceedingly costly, geotextile tubes were used at Barren Island to contain the sediment as a less expensive alternative. Baltimore District desired to contain the Honga River dredged material approximately 200 ft offshore, and determined that placement along the 4-ft contour would be optimal. The tide range in the Barren Island area is about 2 ft. To restore wetlands in the area where the dredged material would be placed, it was determined that the containment structure would need to be 6 ft high. This would allow tidal flushing on high tides, but would prevent the material from eroding out of the placement site. After several discussions with various manufacturers of the geotextile tubes, Baltimore District

concluded that the 6-ft height needed to contain the material could be obtained by using 35-ft-circumference geotube. The geotextile tubes were filled with the dredged material while performing maintenance of the channel.

The initial attempt to contain the dredged material using geotextile tubes occurred in 1989 when the Baltimore District filled some tubes and used a segment configuration to allow for wetland and crenulated bays to establish. The bags were filled using some unorthodox methods that only partially succeeded, and were located in shallow water. The areas behind the tubes were planted with *Spartina* sp. (cordgrass), and the bays formed as anticipated. Areas that were not vegetated and established as a sandy beach supported the nesting of Maryland terrapins.

In 1994, a contract was awarded to allow filling and placing of geotextile tubes along the western side of Barren Island using material dredged from the Federal navigation channel (Figure 2). A medium-sized hydraulic dredge was used that had a 12-in. discharge pipe. The geotextile tubes were placed in the same area as the 1989 location, but in deeper water. The 4-ft contour was used as the line for all additional tubes. A series of geotextile bags were filled to obtain the required height. After installation of the bags, a dredging contract was awarded to pump the remaining material from the channel and place that material behind the geotextile bags. The initial tubes placed in 1989 that had failed were located within the 1994 site, and were covered with this dredged material. After the material was allowed to settle for approximately 1 month, the area was planted with *Spartina alterniflora* (smooth cordgrass) and *S. patens* (salt meadow cordgrass). Initial success occurred as the wetlands thrived. However, erosion of the wetland began to occur in areas where the geotextile bags failed.

By the time of the next maintenance dredging in 2000, the geotextile tubes had become distorted and lost some height. Because of strong wave action, the sand was re-suspended in the bags and forced toward the landward side of the bag, thereby causing stress on the fabric. It was surmised that this was due to the fine-grain material used for filling the tubes. In areas where the bags were lower than mean high water, erosion occurred in the area established as a wetland. Additional bags were needed to extend the placement site. However, it was decided that coarser sand would be required to be placed in the tubes.

Coarse sand was purchased and brought to the site, and used to fill the geotextile bags (Figure 3). The bags were placed end-to-end to create an in-water confined placement site (Figure 4). Even though the bags were constructed according to specifications, the closure structure (snorkel or filling sleeve) could not be kept tied and, when wave action caused this filling sleeve to open, sand was lost and re-suspended once again in the tube. Once more, wetlands species were planted on the dredged material and thrived (Figure 5), but some of the geotubes lost height, which caused wetlands in those areas to erode.

At this point in time, the Baltimore District was successfully using dredged material to restore wetlands along this shoreline. However, use of the geotubes as a containment structure was not entirely satisfactory as they stretched, split, and lost height after they were placed. If the geotubes were torn, the bags also lost sand. Additionally, the cost of purchasing and installing the geotextile tubes was approaching, and sometimes surpassing, the cost to install rock breakwaters. After several attempt to use the geotubes, it was determined that rock would be a better, more stable, and more economically viable alternative for containing the dredged material.

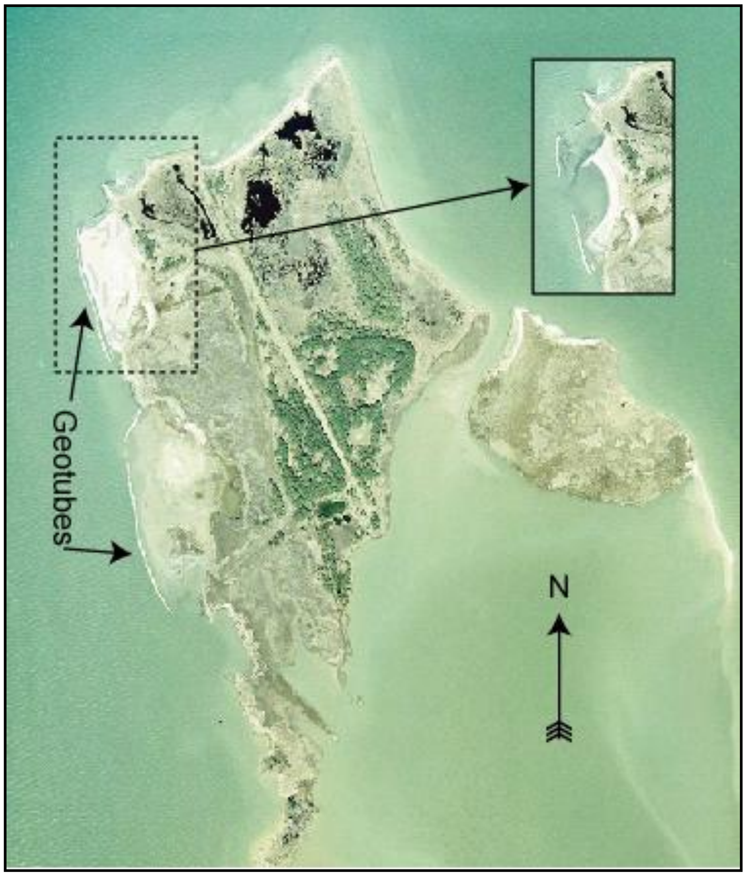

Figure 2. Location of geotextile tubes on western side of Barren Island (photo 1994).

Figure 3. Geotextile tubes fully inflated, before placing dredged material, western side of Barren Island (photo 2000).

Figure 4. Geotextile tubes after dredged material had been placed behind them, western side of Barren Island (photo 2000).

Figure 5. Wetland species planted on dredged material behind geotextile structure, western side of Barren Island (photo 2000).

The northern end of Barren Island had been experiencing heavy erosion and was subjected to some of the worse winds to hit the island. This area did not have any geotextile tubes placed there. The 4-ft contour was again used as the line for placement, and a continuous offshore rock breakwater was constructed in 2003 until it reached some of the surviving geotextile tubes on the western side. Rock was applied to and beyond the area where geotubes were working (Figure 6). Rock was placed anywhere there were gaps in the tubes, and at the end of the tubes. The rock structure was constructed to a height of +2.5 ft above mean lower low water (mllw) with some notches created in the breakwater at a +2.0 ft above mllw to allow for tidal flushing and species ingress and egress. Dredged material placed inside this structure was planted with *Spartina* and *Juncus* (rushes) (Figures 7 and 8). This area has been very successful, and wetlands were established and still thriving with no subsequent loss of the dredged material (Figure 9). Additionally, other features were created within the marsh area. In the area where the pipeline was discharging, a bowl or kettle was formed in the placement site and allowed to stay. When this area was inundated by the tide, a tidal pond was created, which is now used by various aquatic species.

Figure 6. Northern end of Barren Island where stone breakwater was constructed in 2003, dredged material was placed, and planted with *Spartina* (photo August 2005).

Figure 7. Non-planted gaps between *Spartina* plantings, northern end of Barren Island (photo 2005).

Figure 8. *Spartina* filled in gaps between planted areas to cover non-planted areas, northern end of Barren Island (photo 2008).

Figure 9. *Spartina* growth on dredged material placed behind stone breakwater on northern end of Barren Island in August 2008, 3 years after planting.

The National Aquarium of Baltimore has conducted post-monitoring of the placement sites. As of 2006, all previous planted areas continued to thrive, with robust and spreading plant growth. Additionally, there is evidence of colonization by typical marsh fauna, including salt marsh periwinkles, fiddler crabs, killifish, and other species. In particular, areas to the north and south planted in 2004 and 2005 appeared to be thriving, with the plants spreading aggressively beyond the footprint of the original plantings. The only area not exhibiting this strong performance is in the areas on the western side of the Island where the original geotextile tubes have failed or partially collapsed (Figures 10 and 11). These sites continue to erode. In the areas where the failed tubes have been replaced with stone, erosion has been arrested, and the restored marsh is growing landward from the breakwater. In the areas behind the failed tubes, some erosion is ongoing and will likely continue until additional stone is placed in the location of the failing tubes.

Figure 10. Western side of Barren Island where geotextile tubes were installed and failed (photo August 2005).

Figure 11. Dredged material eroded from the placement site after the geotextile tubes failed, western side of Barren Island (photo August 2008).

There was enough room behind the breakwater system initially created that it could contain the 2008 dredging with wetlands established over the entire area. In 2009, American Recovery and Reinvestment Act (ARRA) funds became available and were used to extend the stone breakwaters farther down the Island to some vulnerable areas. Also, wherever geotextile tubes were failing and erosion was occurring, stone was placed in those areas to create pockets of areas that could accept dredged materials.

Keeping sediment in the system as in regional sediment management has allowed for the slowing and, in some areas, the cessation of erosion on Barren Island. By restoring wetlands, the beneficially used material is significantly helping to maintain and restore the ecosystem, and also is providing protection of the mainland.

The USFWS and Friends of Blackwater are working with the National Aquarium in Baltimore, the Baltimore District, and a number of additional partners to restore additional salt-marsh habitat on Barren Island. Goals include wetland restoration, beneficial use of dredge material, and community-based restoration.

CONCLUSION. The Baltimore District continues to seek opportunities to use dredged material beneficially at Barren Island, and wherever else there are potential sites available. Using dredged material in a manner that keeps it in the littoral system supports the major goal of the Regional Sediment Management (RSM) program of the US Army Corps of Engineers, and is consistent with other Chesapeake Bay restoration efforts.

ADDITIONAL INFORMATION. This Coastal and Hydraulics Engineering Technical Note (CHETN) was prepared as part of the Regional Sediment Management (RSM) program, and was written by Robert N. Blama, US Army Engineer District, Baltimore, MD. The work was supported by multiple entities including the Baltimore District, Chesapeake Bay Field Office of the Baltimore District, US Fish and Wildlife Service, Friends of Blackwater, National Oceanic and Atmospheric Administration, and the National Aquarium in Baltimore, MD. Additional information pertaining to the RSM program can be found at the RSM web site http://rsm.usace.army.mil

Questions pertaining to this CHETN may be addressed to:

Robert N. Blama	robert.n.blama@usace.army.mil
Linda S. Lillycrop (RSM Program Manager)	Linda.S.Lillycrop@usace.army.mil

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ACRONYMS AND ABBREVIATIONS.

Term	Definition
ACES	Automated Coastal Engineering System
CHETN	Coastal and Hydraulics Engineering Technical Note
CHL	Coastal and Hydraulics Laboratory
ERDC	Engineer Research and Development Center
MHT	Mean High Tide
MLLW	Mean Lower Low Water
MPA	Maryland Port Administration
O&M	Operations and Maintenance
RSM	Regional Sediment Management
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service